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SOILLESS GROWTH OR HYDROPONICS

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A number of different terms have been applied to this way of growing plants, depending upon the media employed and the technique adopted. Some of these terms are hydroponics, water culture, sand culture, cinder culture and soilless growth. These methods may be roughly divided into two groups: growing plants with the root systems immersed in water, in which the essential plant nutrients have been dissolved; and growing plants with the root system supported in a solid medium such as sand, cinders or gravel.

Hydroponics or water culture

This method consists essentially of supporting the plants with their roots dipping into a tank or container of nutrient solution. Containers may be made of wood, glass, concrete or metal. The plants may be suspended by baskets made of ungalvanized wire screen which are fastened or hooked onto the rims of the containers. The plants may be supported in the basket by 5-8 cm of excelsior, straw or other material of little nutrient value. The tank containing the solution should be kept dark to prevent the growth of algae. If individual plants are being grown in small glass containers in the home, they may be supported by fitting a cork, a piece of wood or other material to rest on the rim of the bowl. The plant is inserted through a hole in the centre and cotton is wrapped around the stem of the plant at the point where it passes through this support. Tanks may be waterproofed by painting with a pure petroleum asphalt which will at the same time prevent lime or toxic substances from being dissolved into the nutrient solution. A tank 2 m long by 0.3 m X 0.3 m with a ledge near the top to support the wire basket will be found suitable.

It is necessary that means of aeration or a supply of oxygen be furnished to the roots. In the water culture method, this is not so easily accomplished, since the roots are constantly immersed in the nutrient solution and it is difficult to make water absorb air. If plants are grown in individual small containers, it may suffice to block up the plant with its support from the top of the bottle. In larger tanks, aeration may be accomplished by some mechanical process, such as agitating the solution vigorously or keeping it in constant circulation by pumping the solution into a tower and allowing it to fall by gravity over some kind of grating, or actually forcing air into the solution with a pump.

In addition, it is necessary to maintain the culture solutions at a temperature favorable for root growth; that is, at a temperature of 21-27°C. This may be accomplished by the use of an immersion heater regulated by a thermostat.

A formula which has proved successful with a large number of vegetables and flowering plants is made up as follows:

Dissolve the following salts separately in about 1 L of water. The solutions are then mixed and diluted to 25 L with water.

10 mL superphosphate
5 mL sodium nitrate
12 mL magnesium sulfate
5 mL potassium chloride

To the above, 5 mL of the following solution is added:

5 mL each of boric acid and manganese sulfate dissolved in 2 L of water.

As the plants grow, the nutrient solution will become spent, and must be discarded and replaced at intervals of three to four weeks.

It has been found that this method is not as successful in areas where there are a number of consecutive cloudy days, as in sections where the weather is continually bright. This method has not been largely adopted by commercial growers, owing to the initial expense involved and to the factors of aeration and temperature which must be maintained.

Sand culture

Three adaptations of the sand culture method may be employed.

Method I – Solid fertilizers. Before transplanting into sand, most of the soil is removed from the roots. Nutrients applied in solid form are less quickly available to the plant than when applied in solution. For this reason, an application is made to the sand some ten days to two weeks before the plants are set out. During this period, the sand is kept moist. After the plants are set out, applications of fertilizer are made at intervals of two to three weeks at the rate of 17 g/m^2. This amount and frequency of application has proven very suitable, but could be varied at the discretion of the grower, according to growth, influenced by climatic factors. Watering with ordinary tap water is given when necessary and is supplemented by a thorough drenching or leaching before each application of fertilizer to ensure that toxic concentrations of salts do not occur.

Formula to make up approximately 10 kg of fertilizer:

Ammonium sulfate	5.58 kg
Muriate of potash	1.48 kg
Superphosphate 20%	1.26 kg
Magnesium sulfate	1.45 kg
Boric acid	8 g
Manganese sulfate	3 g

A few drops of 1% solution of ferric chloride or ferrous sulfate used in the tap water will provide all the necessary iron.

Method II – Nutrient solution applied at intervals. During the early stages of growth, the solution is applied at the rate of 5 L/m^2 once a week. As growth progresses, the rate is increased to 10 L/m^2 once a week. In addition to the nutrient solution the beds receive tap water when necessary. The regular waterings are supplemented every two weeks by a thorough drenching in order to prevent the accumulation of excess salts.

Formula to make up 200 L of solution:

Ammonium sulfate	1.12 kg
Muriate of potash	300 g
Superphosphate 20%	340 g
Magnesium sulfate	190 g
Boric acid	1 g
Manganese sulfate	0.1 g
Ferric chloride	3 g

Each salt should be dissolved separately in a litre or so of water, mixed together and made up to 200 L.

Method III – Nutrient solution employed to retain required moisture content of the sand bed. This solution is employed as tap water would be employed to maintain the required moisture content of the sand. The same formula is employed as for Method II, but only 1/6 the quantity of fertilizer is employed in the same quantity of water or the same solution is diluted with five volumes of water.

These methods with the accompanying formulas have been employed very successfully with chrysanthemums, carnations and a number of vegetables such as tomatoes and lettuce. These three adaptations of the sand culture method are the simplest of various soilless growth methods. Since no change is required in bench construction and no pumps or other special equipment is required, they constitute the most inexpensive method of starting soilless growth.

They have the disadvantage that some of the nutrient or fertilizer salts are lost in draining the excess solution out of the bench and by the leaching process; furthermore, there is no saving in the labor of watering.

Cinder or gravel culture

This system consists of waterproof benches filled with cinders or gravel and a subirrigation method of delivering the nutrient solution. At a centrally located point, and definitely lower than the benches, is a waterproof concrete tank constructed to hold the nutrient solution. In a separate compartment alongside is located an electrically driven centrifugal pump. A single run of pipe goes to each bench to be supplied from the tank. At each bench this pipe discharges under an inverted trough which rests on the bottom of the bench and extends its entire length. This inverted trough helps to distribute the solution uniformly throughout the bench. The pump which forces the solution into the benches may be operated by a time clock. As the solution is forced into the benches, air is forced out of the cinders or gravel and as the solution drains from the benches, air is drawn back into the cinders or gravel, resulting in good root aeration. It is not necessary to water the plants, as this is accomplished by pumping the solution to them. There is no loss of nutrients or water, and manual labor required for watering is eliminated.

Instead of forcing the nutrient solution up through the bed, it may be pumped through a perforated pipe, lying on the surface of the bed, the excess solution draining back into the solution tank. Benches should not be flooded more frequently than is necessary to maintain the supporting medium at a suitable moisture content.

Benches

If new benches are being built, concrete is the easiest to waterproof. Benches should have 15-cm sides and an approximate slope of 1 cm to 12 m. In the case of wooden benches, cracks in the bottom may be covered with lath and the bottom edges reinforced. Then the sides and bottom are covered with heavy plastic sheeting.

Solution tank

The tank should be completely waterproofed, made of concrete and painted inside with a pure petroleum asphalt, which prevents the lime in the cement and gravel from neutralizing the acid in the nutrient solution. The tank should have a capacity of at least one-third the cubic content of the bench. The inflow pipe should be 25 mm in diameter and enter the bench at one end. Avoid galvanized pipe and connections due to possible toxic action from zinc.

Media

Cinders have been employed with considerable success, although they vary in accordance with the coal from which they come. They are frequently alkaline and precipitate iron and phosphorus. The size should be 15-20 mm. After the benches are filled with screened cinders, they should be flooded with clear water and allowed to stand for a couple of days. At the end of this time, drain and refill with fresh water, allowing it to stand in the benches another two days. If the cinders are alkaline in reaction, the benches may be filled with water to which 3 L of concentrated sulfuric acid is added per 1000 L of water and left for two days before draining. Instead of treatment with sulfuric acid, the cinders may be flooded several days with a phosphorus solution, 1 kg of monocalcium phosphate (Food Grade) to 1000 L of water.

Gravel. Noncalcareous or lime-free gravels are often difficult to obtain. Because of alkalinity, precipitation of iron and phosphorus frequently occurs. If the gravel is alkaline, it may be treated with a phosphorus solution as described for cinders.

Nutrient solution

The formula given in Method III for sand culture has proved satisfactory for growing carnations by this method, but there is no one solution that will grow all crops to the best advantage. Information regarding the growth of a particular crop by this method may be obtained by application to the Research Branch, Central Experimental Farm, Ottawa.

Further details regarding these various methods of soilless growth may be secured by consulting *Soilless Growth of Plants* by Ellis and Swaney, and *Growing Plants in Nutrient Solutions* by Turner and Henry.

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